

**Early Growth of Chum Salmon
(*Oncorhynchus keta*) Fry Fed Two
Commercial Diets and Three Experimental
Dry Diets at Three Temperatures**

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EARLY GROWTH OF CHUM SALMON (Oncorhynchus keta) FRY
FED TWO COMMERCIAL DIETS AND THREE EXPERIMENTAL
DRY DIETS AT THREE TEMPERATURES

by

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ABSTRACT

Shelbourn, J. E., D. A. Higgs, W. C. Clarke, B. S. Dosanjh, and J. R. Markert. 1985. Early growth of chum salmon (*Oncorhynchus keta*) fry fed two commercial diets and three experimental dry diets at three temperatures. Can. Tech. Rep. Fish. Aquat. Sci. 1412: 17 p.

Chum salmon fry were held indoors in replicate pairs of tanks in fresh water at 4°, 8° and 12°C. They were fed one semimoist commercial diet, one dry commercial diet or one of three protein-substituted test dry diets.

Excellent growth was obtained with the Oregon Moist Pellet and Silver Cup (dry) diet, while three test dry diets with either pollock meal, herring meal or poultry by-product plus feather meal as the major protein source provided progressively reduced growth in that order. The Oregon Moist Pellet diet supported the best growth at 4°C and fry fed Silver Cup grew larger at 8° and 12°C.

Whole body proximate composition at termination was significantly different in response to diet type, but was less variable than growth in body weight. Rearing temperature affected final percentages for body moisture and lipid, but did not affect those for body protein.

The significance of dietary texture and composition is discussed, and we conclude that there is a potential advantage in using protein-substituted dry diets for chum salmon fry, provided that the composition is optimal and rearing temperatures exceed 4°C.

RÉSUMÉ

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Des alevins de saumon keta ont fait l'objet d'essais d'alimentation en cuves appariées et dédoublées placées à l'intérieur et contenant de l'eau douce maintenue à 4, 8 et 12°C. On a administré aux alevins une nourriture du commerce semi-humide, une nourriture du commerce sèche ou l'une des trois nourritures d'essai sèches à protéines de substitution.

Les nourritures Oregon Moist Pellet (humide) et Silver Cup (sèche) ont permis d'obtenir un excellent taux de croissance. Les taux de croissance obtenus avec les nourritures d'essai décroissaient dans l'ordre de la principale source de protéines à savoir: farine de goberge, farine de hareng ou sous-produits de poulet additionnés de farine de plumes. La nourriture Oregon Moist Pellet a permis d'obtenir la meilleure croissance à 4°C tandis que la Silver Cup donnait les meilleurs résultats à 8 et 12°C.

La composition approchée de l'ensemble de l'organisme à la fin de l'essai variait de façon significative en fonction du type d'alimentation, mais cette variation était moins importante que celle du taux d'accroissement du poids corporel. La température d'élevage avait une incidence sur les pourcentages définitifs des teneurs en eau et en lipides mais non ceux des teneurs en protéines.

Les auteurs traitent de l'importance de la texture et de la composition de la nourriture et concluent qu'il pourrait être avantageux d'utiliser de la nourriture sèche à protéines de substitution pour l'alimentation des alevins de saumon keta à condition que la composition soit optimale et que la température d'élevage soit supérieure à 4°C.

INTRODUCTION

Several decades ago the development of fish feeds included relatively expensive sources of protein in order to attempt to duplicate natural food: small fishes, aquatic animals or processed domestic animals, for example. Later, dried meals of animal and plant origin were added to meat by-products in order to reduce costs (Hastings and Dickie 1972).

Diets for chum salmon have been preferred in semimoist form (ca. 30% moisture) on the west coast of North America, with the Oregon Moist diet being found superior in Washington State (Mathews and Senn 1975). However, dry diets (<10% moisture) are preferred in Japanese chum hatcheries. Dry diets have the advantage of being storable without refrigeration, with an obvious saving in expense over moist feeds. It is not known whether chum fry reared at lower water temperatures (<6°C) will feed and grow well on dry diets, or whether they will perform better on semimoist feeds. Japanese chum hatcheries in Hokkaido use spring water with a temperature around 8°C (Mathews and Senn 1975).

Salmonid diets require relatively high amounts of protein. For example, Akiyama et al. (1981) report that at 9.4° and 16.3°C chum fry need 43% of dietary dry matter as protein, with lipid at 5% and 10% at the two temperatures respectively.

In the case of trout starter diets it is considered essential to leave fishmeal unreplaced in the diet up to the 35% level, although the use of less costly protein sources is desirable (Hilton and Slinger 1981). Previous studies on trout (Tiews et al. 1979), on coho (Higgs et al. 1979) and on chinook (Fowler 1982) salmon suggest that fish meal may be replaced to some extent by protein from a blend of poultry by-product meal and feather meal without compromising performance.

The current experiment examined both the effect of diet moisture content and the influence of completely replacing commercial fishmeal by cheaper high protein meals on growth in young chum salmon. The replacement meals were incorporated in three test dry diets manufactured in the laboratory, with the major protein component originating from either pollock meal, herring meal, or a blend of poultry by-product and feather meal. The two commercial diets were the Oregon Moist Pelleted diet and Silver Cup dry diet. All the diets contained approximately 50% protein and 15% lipid on a dry weight basis.

MATERIALS AND METHODS.

Chum salmon eggs were obtained from the Nanaimo River hatchery in the fall of 1979 and were incubated at the Pacific Biological Station, Nanaimo, B.C.

Swim up commenced on 6 March. On 10 March 1980, free-swimming fry were selected for uniform size and approximately 100 fish were distributed randomly into each of 30 197-l culture tanks. At this time 200 fry were removed from the stock tank for zero time proximate analysis (Table 4A). Treatments were then randomly assigned to the tanks, establishing 15 replicate pairs.

During the next week the fry were acclimated to 4, 8 and 12°C at a rate of change of 1°C per day, and were fed commercial OMP mash ad libitum. Temperature control was achieved by mixing laboratory water supply lines appropriately. Daily readings of tank temperature were taken with a thermometer calibrated to 0.1°C.

Photoperiod control was provided by laboratory light timers set to approximate the natural daylength.

On 17 March, all the fry in each tank were lightly anesthetized in a 2-phenoxyethanol solution (approx. 0.5 cc/L) after 24 h food deprivation, momentarily rolled on a dampened chamois to remove surface moisture, then weighed individually to .01 g.

After this initial weighing, feeding commenced with the five experimental diets described below.

The three test diets with substituted protein were prepared in the laboratory according to the procedures of Higgs et al. (1979), with protein and lipid content similar (on a dry weight basis) to the two commercial diets fed for comparison: OMP and the Silver Cup dry diet (SC) (Table 1).

Most of the protein in the three test diets stemmed either from commercially produced poultry by-product meal and feather meal (WVF), flame-dried herring meal (WVH), or partially deboned steam-dried pollock meal (WVP). All three test diets contained additional protein from freeze-dried euphausiids and wheat mill run: the former is thought to improve diet palatability for young fish, while the latter is commonly included in dry diets to facilitate pellet binding. Diet formulations are listed in Tables 1A and 1B, while proximate composition and mineral levels are provided in Table 2.

Fish were fed by automatic feeders three times daily to excess, with care being taken to offer food in abundance. No attempt was made to estimate food consumption.

The tanks were routinely cleaned by siphon to minimize the accumulation of debris. There was occasional loss of fish through this procedure, but mortalities were below 5% in all groups. Regardless of the experimental treatment, the fish showed no signs of poor health and were thus not examined for the presence of infectious disease nor for histopathology.

At the end of the experiment the fish were weighed as described previously, and samples of five fish from each combination of diet and temperature and samples of each diet were taken for proximate analysis (Table 4B).

RESULTS

Mean tank temperatures, initial and final mean wet weights, and specific growth rates are shown in Table 3, along with analysis of variance of the growth rates. Mean wet weight gains for each replicate are shown in Figure 1, along with gains taken from Shelbourn (1980) for comparison of the present results with previous data on chum fry fed OMP (interpolated for 4, 8 and 12°C).

In some cases, the growth responses of the groups were highly variable between replicates, e.g. the specific growth rates at 4°C for some of the diets (Table 3A). However, analysis of variance showed the effect of replication to be non-significant ($p > .05$). Factorial analysis of variance (Table 3B) showed highly significant effects of diet as well as temperature, with a highly significant interaction between diet and temperature. The WVF diet supported poorest growth at all temperatures, especially at 4° and 8°C. This undoubtedly contributed to the significant TxD Interaction term in the analysis of variance (Table 3B). The noted sequence for the growth rate means across all temperatures is as follows: SC > OMP > WVP > WVH > WVF. In addition, it is noteworthy that the SC diet supported the best growth at 8° and 12°C, whereas at 4°C the fish fed OMP exhibited the highest growth rates.

Initial and final percentages for carcass moisture, and percentages of lipid and protein on a moisture free basis are shown in Table 4. Analysis of variance indicated a significant difference between replicates for carcass moisture ($F = 5.0$, tabulated $F(0.5) = 4.6$), while differences between replicates in the protein and lipid data were non-significant. Factorial analysis of variance of these constituents is presented in Table 5, where it can be seen that there was less variation in the body proximate composition data than was noted for growth rate. Nonetheless, the effect of diet was significant for moisture, lipid and protein, and there was no interaction between diet and temperature. Percentage body protein was not significantly influenced by rearing temperature, while temperature significantly affected percentages for moisture and lipid.

DISCUSSION

Referring to Figure 1, it is apparent that irrespective of diet treatment there was an increase in weight gain with increasing temperature, but the maxima for fish fed the three test diets at each temperature did not reach those of the two commercial ones except at 4°C. Here the growth responses were not statistically separable by multiple range test ($p < .05$). The weight gains of chum fed OMP and Silver Cup in this study relative to those calculated from previously established results for chum fry in this laboratory were similar. However, the growth rates presented for comparison

are conservative estimates, since they were estimated for chum fry with a starting weight varying from 0.6 to 1.3 g (Shelbourn 1980; Bams 1984) compared with 0.3 g in the present study.

Regarding the effect of diet texture on performance, it was noted that the growth responses to OMP and Silver Cup were similar at 8° and 12°C whereas the groups fed the experimental dry diets at these temperatures had reduced growth (Fig. 1), which suggests that the diet composition may have been of greater significance than moisture content or texture (hardness) in determining the growth response. This conclusion agrees with the findings of Higgs et al. (1985) for pink salmon fry. At the lowest temperatures in the current study, namely 4°C, the fry fed OMP exhibited slightly better growth than those fed Silver Cup. Hence a softer textured diet may provide improved growth at low temperature. Studies which have shown good growth of salmonids in response to dry diets have generally been conducted at temperatures of over 8°C. Some examples of these include work on coho (Markert et al. 1984), chum (Murai et al. 1980), trout (Reinitz and Hitzel 1980), pinks (Higgs et al. 1985) and chinook (Fowler 1982). From a practical standpoint it may be undesirable to rear chum salmon at low temperatures prior to sea release owing to their small size. But if low temperatures are unavoidable, semimoist diets would be preferred as a starter feed until dry diets have been demonstrated to be equally satisfactory.

With respect to the effect of diet composition on performance, it is likely that both the type and the level of carbohydrate inclusion in the test diets were responsible for some reduction in growth performance. Each diet contained a high proportion of wheat mill run (19-24%). High levels of wheat middlings, a product similar in composition to mill run, are commonly used to facilitate pellet binding in rainbow trout diets without compromising performance. But the inclusion of a high level of mill run in salmon diets may reduce the digestible energy content and palatability of the diet, even though the diets also contained freeze-dried euphausid, which is thought to enhance appetite. Cho and Slinger (1979) noted that a large proportion of mill run (>15%) in rainbow trout feed may reduce digestibility. The increased level of fiber in test diets may have increased gut mobility in rainbow trout and thus reduced time for food absorption (Hilton et al. 1983).

The different sources of protein used in our test diets might have produced good growth in the chum fry but for the inhibiting effect of the excessive mill run. Evidence in the literature is supportive of the efficacy of substituting fishmeal by protein from other sources in producing successful growth. For example, in chum fry diets Akiyama et al. (1984) substituted non-marine protein for marine protein, and Murai et al. (1980) replaced fishmeal with casein or krill meal. For other salmonids, Higgs et al. (1979) partially replaced herring meal with poultry by-product meal in diets for coho fry, Clarke et al. (1982) partially replaced fishmeal with poultry by-product meal, feather meal, blood meal and soybean meal in coho fry diets, and Schulz et al. (1982) included blood meal and feather meal in diets for rainbow trout. In the latter study increased growth was obtained in comparison with a standard casein diet.

From the carcass proximate analysis data presented in Table 4, it appears that the greater variation in growth (Table 3) compared with final body composition was probably a reflection of either the low palatability of the test diets or their poor overall digestibility, rather than the unavailability of the feed protein per se to the fish. Although food consumption was not measured, making food conversion data unavailable, the efficacy of the diets in providing good growth is shown by the high carcass protein content. Groves (1970) stated that in the starving fish body both water and protein are lost. In our case (Table 5) carcass protein content was in fact slightly higher in fish fed the test diets. There was significant variation in moisture values ($p < .05$), being least in the fish fed OMP and greatest in those fed WVF, but considering the narrow range of the mean terminal moisture levels (0.83%) this was probably not of practical significance.

In conclusion, it appears that the starter diets tested in this experiment provided good nutrition, according to carcass proximate analysis, but poor growth in size. Moreover, it appears that there is good potential for employing dry diets for culturing young chum salmon, providing that careful attention is paid to the type, level and quality of the dietary components included. At this time it is recommended that high levels of plant protein be avoided in salmon starter diets without further research. Chum salmon may require soft textured diets at water temperatures below 4°C, although this aspect still needs further definition.

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Table 1. Composition of the 5 experimental diets.

A. Test diets manufactured in the West Vancouver Laboratory			
Ingredients	Diets		
(g/kg dry diet)	WVF	WVH	WVP
Poultry by-product meal (CP ^a = 71.9%)	361.32	-	-
Feather meal (CP = 91.4%)	196.94	-	-
Herring meal (CP = 71.4%)	-	616.0	-
Pollock meal (CP = 84.6%)	-	-	520.1
Freeze-dried euphausids (CP = 62.1%)	40.0	40.0	40.0
Wheat mill run (CP = 18.7%)	233.44	193.8	237.76
Herring oil-stabilized	74.5	67.6	106.14
Vitamin supplement ^b	40.0	40.0	40.0
Mineral supplement	20.0 ^c	20.0 ^d	20.0 ^e
Permapell (lignin sulfonate binder)	20.0	20.0	20.0
DL-methionine	2.8	2.6	-
CaCO ₃	-	-	5.6
CaHPO ₄ ·2H ₂ O	-	-	10.4
K ₂ HPO ₄ ·3H ₂ O	11.0	-	-

^aCrude Protein

^bVitamin supplement as mg/kg dry diet unless otherwise indicated:

50% choline chloride* 3456; biotin 3; pyridoxine HCl 36.5; vitamin B12 (cyanocobalamin) 0.06; vitamin C* (ethocel coated) 1000; vitamin E 600 iu; folic acid 20; inositol 400; menadione 80; niacin 300; D-calcium pantothenate 164; riboflavin 60; thiamin HCl 34; vitamin A 10,000 iu; vitamin D3 (cholecalciferol) 1000 iu; and α-cellulose filler.

^cMineral supplement provided the following levels of minerals (mg/kg dry diet): P (as NaH₂PO₄·H₂O) 694; Mg (as MgSO₄) 518; Zn (as ZnSO₄·7H₂O) 20.8; I (as KI) 4.5; Na (as NaCl and from NaH₂PO₄·H₂O) 2666; Al (as AlCl₃·6H₂O) 13.3.

^dMineral supplement provided the following levels of minerals (mg/kg dry diet): Mg (as MgSO₄) 1272; Zn (as ZnSO₄·7H₂O) 55.9; Co (as CoCl₂·6H₂O) 0.33; Cu (as CuSO₄·5H₂O) 8.7; I (as KI) 4.5.

^eMineral supplement provided the following levels of minerals (mg/kg dry diet): Zn (as ZnSO₄·7H₂O) 26.6; Cu (as CuSO₄·5H₂O) 1.4; I (as KI) 4.5; Na (as NaCl) 2161; Al (as AlCl₃·6H₂O) 18.3.

*added to mash prior to pelleting.

Table 1 (cont'd)

B. Manufacturer's stated contents of commercial diets*		
OMP ^f (g/kg as fed)		Silver Cup (SC) ^g
<u>Dry ingredients:</u>		(closed formula)
Fish meal	280-300	Herring and anchovy meal
Cottonseed meal	170	Blood meal
Wheat germ meal	40	Cottonseed meal
Dried whey	50	Soybean meal
Shrimp/crab meal	40	Wheat flour
Corn distillers		Anchovy and/or tuna oil
dried solubles	20-40	Mineral and vitamin mix
Vitamin premix ^h	15	Lignin sulfonate (binder)
<u>Moist ingredients:</u>		
Wet fish	300	
Marine/soya oil	60	
Choline chloride, (liq., 70% product)	5	

*Mention of commercial products does not imply endorsement by the Department of Fisheries and Oceans, Canada.

^f Oregon Moist Diet, manufactured by Moore-Clarke Co., La Conner, Washington, USA.

^g Silver Cup dry feed, manufactured by Murray Elevators, Murray, Utah, USA.

^h Vitamin supplement to the OMP diet supplied the following levels of nutrients (as mg/kg dry diet unless otherwise indicated):
 α -tocopheryl acetate 717 iu, menadione sodium bisulfate complex 25.7, pantothenic acid 151, vitamin B6 25.2, riboflavin 75.5, niacin 269, folic acid 18.2, thiamine 33.7, biotin 0.85, vitamin B12 85 μ g, myo-inositol 378, vitamin C 1274.

Table 2. Proximate composition and mineral content (g/kg) of experimental diets. Means $\pm$ s.e. shown for proximate composition data^a.

	Diet ^b				
	WVF	WVH	WVP	OMP	SC
<u>Proximate analysis</u>					
<u>(% dry matter)</u>					
Protein	49.5 $\pm$ 0.02	52.2 $\pm$ 0.9	49.3 $\pm$ 0.2	49.5 $\pm$ 0.1	54.3 $\pm$ 1.4
(%N X 6.25)					
Crude lipid	15.2 $\pm$ 0.2	17.1 $\pm$ 0.9	14.2 $\pm$ 0.3	19.0 $\pm$ 2.2	16.2 $\pm$ 1.0
(Bligh-Dyer)					
Ash	8.2 $\pm$ 0.3	12.5 $\pm$ 0.4	8.4 $\pm$ 0.2	12.7 $\pm$ 0.2	10.5 $\pm$ 0.3
Moisture	10.9 $\pm$ 0.1	10.5 $\pm$ 0.1	10.8 $\pm$ 0.1	23.0 $\pm$ 4.8	4.7 $\pm$ 0.4
<u>Mineral content</u>					
Calcium (Ca)	16.1	24.6	16.5	23.4	-
Phosphorus (P)	11.5	17.3	11.8	17.2	-
Magnesium (Mg)	2.1	3.2	2.2	3.1	-
Iron (Fe)	0.28	0.41	0.22	0.20	-
Sodium (Na)	4.7	10.8	5.4	8.8	-
Copper (Cu)	0.015	0.020	0.012	0.011	-
Manganese (Mn)	0.032	0.029	0.030	0.025	-
Cobalt (Co)	0.002	0.001	0.001	<0.001	-
Zinc (Zn)	0.101	0.130	0.080	0.072	-
Ca:P	1.4	1.4	1.4	1.4	-
P:Mg	5.5	5.4	5.4	5.6	-
Ca:Mg	7.7	7.7	7.5	7.6	-

^a Mineral levels determined by plasma spectroscopy. Mineral composition of SC not determined.

^b For explanation of abbreviations, see text.

Table 3A. Mean tank temperatures, initial and final mean fish weights, and specific growth rates for each diet and temperature.

Diet (see text)	Mean temp, °C		Initial wet weight (g)		Final wet weight (g)		Specific growth rate, G(%/d) ^a	
	rep 1	rep 2	rep 1	rep 2	rep 1	rep 2	rep 1	rep 2
WVF	4.14	4.19	.285	.275	.308	.299	.32	.35
	8.05	7.91	.270	.290	.316	.367	.66	.98
	11.91	11.81	.301	.315	.536	.591	2.40	2.62
WVH	4.26	4.30	.278	.266	.362	.285	1.10	.29
	8.13	7.98	.307	.285	.505	.472	2.07	2.10
	12.10	11.87	.307	.315	.809	.701	4.04	3.33
WVP	4.17	4.24	.282	.273	.333	.302	.69	.42
	8.14	8.01	.311	.314	.562	.535	2.47	2.22
	11.95	12.01	.375	.350	.909	.874	3.69	3.81
OMP	4.23	4.28	.285	.293	.392	.398	1.33	1.28
	8.10	7.96	.324	.324	.691	.641	3.16	2.84
	11.85	11.80	.351	.374	1.099	1.152	4.76	4.69
SC	4.13	4.31	.277	.276	.364	.345	1.14	.93
	8.06	7.97	.320	.286	.661	.642	3.02	3.37
	11.97	11.95	.304	.360	1.063	1.160	5.22	4.88

$$^a G = \frac{\log_e WW \text{ (final)} - \log_e WW \text{ (initial)}}{24 \text{ (d)}} \times 100$$

Table 3B. Replicate means and factorial analysis of variance of specific growth rates.

Diet	Table of means			Mean
	4°C	8°C	12°C	
WVF	0.31	0.78	2.50	1.20
WVH	0.65	2.09	3.67	2.14
WVP	0.55	2.34	3.75	2.21
OMP	1.27	2.98	4.68	2.98
SC	1.02	3.16	5.01	3.06
Mean	0.76	2.27	3.92	

Factorial analysis of variance table

Source	d.f.	Mean square	F	F(.05)
Temperatures	2	24.97	437.3	6.5
Diets	4	3.44	60.9	5.0
T x D Interaction	8	0.29	5.1	4.1
Error	14	0.06		

Note: all data have been rounded after computation.

Table 4. Whole body proximate analysis of chum fry according to diet and temperature treatment.

A. Initial sample (lipid and protein as percentage dry weight)

77.30% moisture, 24.66% lipid, 65.37% protein

B. Final sample (lipid and protein as percentage dry weight)

Diet	T°C	Rep 1			Rep 2		
		Moisture (%)	Lipid (%)	Protein (%)	Moisture (%)	Lipid (%)	Protein (%)
WVF	4	83.30	14.49	78.26	82.19	15.39	81.68
	8	83.20	12.38	79.52	83.11	13.87	75.71
	12	82.88	14.84	78.86	82.03	14.43	79.67
WVH	4	82.49	13.59	74.41	83.37	11.88	70.13
	8	82.28	14.45	79.06	82.19	14.67	76.52
	12	81.83	15.58	75.29	81.09	16.84	75.34
WVP	4	82.58	14.18	76.18	82.27	13.26	77.78
	8	81.96	15.52	72.17	82.50	13.25	74.72
	12	82.15	16.13	76.81	81.79	16.30	79.78
OMP	4	83.18	14.39	81.33	82.53	15.52	75.86
	8	82.56	15.94	74.37	82.02	16.06	77.24
	12	81.32	18.09	70.24	80.12	21.68	75.27
SC	4	82.37	16.96	76.46	82.58	13.22	72.94
	8	82.37	17.92	71.07	82.13	15.94	72.60
	12	81.55	18.05	71.65	81.15	19.89	74.09

Table 5. Replicate means and factorial analysis of variance of percentage carcass moisture, and dry weight percentage of lipid and protein.

<u>Carcass moisture</u> <u>(%)</u>	Diet	4°C	8°C	12°C	Mean
WVF		82.75	83.16	82.46	82.79
WVH		82.93	82.24	81.46	82.21
WVP		82.43	82.23	81.97	82.21
OMP		82.86	82.29	80.72	81.96
SC		82.48	82.25	81.35	82.03
Mean		82.69	82.43	81.59	

Factorial analysis of variance table.

Source	d.f.	Mean square	F	F(.05)
Temperatures	2	3.28	20.0	3.7
Diets	4	0.64	3.9	3.1
T x D Interaction	8	0.33	2.0	2.7
Error	14	0.16		

Lipid
(% dry
weight)

Diet	4°C	8°C	12°C	Mean
WVF	14.94	13.13	14.64	14.23
WVH	12.74	14.56	16.21	14.51
WVP	13.72	14.39	16.22	14.77
OMP	14.96	16.00	19.89	16.95
SC	15.09	16.93	18.97	17.00
Mean	14.29	15.00	17.18	

Factorial analysis of variance table

Source	d.f.	Mean square	F	F(.05)
Temperatures	2	22.76	13.9	3.7
Diets	4	11.19	6.8	3.1
T x D Interaction	8	2.39	1.5	2.6
Error	14	1.64		

Table 5 (cont'd)

<u>Protein</u> <u>(% dry</u> <u>weight)</u>	<u>Diet</u>	<u>4°C</u>	<u>8°C</u>	<u>12°C</u>	<u>Mean</u>
WVF		79.97	77.62	79.27	78.95
WVH		72.27	77.79	75.32	75.13
WVP		76.98	73.45	78.29	76.24
OMP		78.60	75.81	72.76	75.72
SC		74.70	71.84	72.87	73.14
Mean		76.50	75.30	75.70	

Factorial analysis of variance table

<u>Source</u>	<u>d.f.</u>	<u>Mean square</u>	<u>F</u>	<u>F(.05)</u>
Temperatures	2	3.76	0.7	3.7
Diets	4	26.51	5.2	3.1
T x D Interaction	8	12.08	2.4	2.6
Error	14	5.12		

Note: in all tables, data have been rounded after computation.

FIGURE CAPTIONS

Fig. 1. Wet weight gains for each replicate at temperature indicated in legend, grouped according to diet.

Legend:  4°C
  8°C
  12°C

* extrapolated from Shelbourn (1980).

Note: Bar pairs with the same superscript are not significantly different when compared by multiple range test ($p > .05$). For details regarding diets, see text.

